UTILIZATION OF THE EARTH'S NATURAL HEATING SYSTEM TO DESALT GEOTHERMAL BRINES FOR AUGMENTATION OF THE COLORADO RIVER SYSTEM*

by
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ABSTRACT

Desalting of geothermal fluids underlying the Imperial Valley of California represents an answer to water quality problems in the Colorado River Basin as well as a potential source of water supply. The paper outlines a three-stage program for water production from the geothermal resources stored in the subterranean aquifers of Imperial Valley. The first stage, now in progress, is the research and development stage. Two exploratory geothermal wells were drilled, and two test desalting units, a multistage flash unit and a vertical tube evaporator, were installed. Beginning its operation in Summer 1973, the multistage flash unit desalted, for the first time in history, geothermal brine under actual field conditions. The design, construction, and initial operation of the geothermal wells, desalting units, and associated facilities are described. Finally, the paper discusses proposed future work, developmental problems, and prospects for multipurpose exploitation.

INTRODUCTION

Shortages seem to be the subject of most discussions in the news today — shortages of energy, shortages of food, shortages of paper, and many other items of once-plentiful supply. Few discussions, however, are about shortages of good quality water, but unless we plan intelligently now, water may be one of our most critical shortages.

The Bureau of Reclamation, as one of the Nation's major water resource agencies, is actively involved in programs to help avoid major water shortages. One program presently under investigation has the potential of providing a source of augmentation water for the Lower Colorado River through the desalting of geothermal fluids stored in the subterranean aquifers of Imperial Valley, California. Under the Colorado River Basin Project Act (P.L. 90-537, 82 Stat. 885, September 30, 1968), the Bureau has a statutory responsibility to investigate alternate water supplies to supplement the Colorado River. Geothermal development would augment the river from sources within the basin.

CONCERNS IN THE COLORADO RIVER BASIN

The Colorado River is the life blood of the Pacific Southwest and is a river heading for trouble. The Colorado River Compact allocates more water per year for consumptive use by the seven basin states than the runoff records of recent decades indicate are available. There is also an international obligation to deliver 1.5 million acre-feet of water annually to satisfy the requirements of the Mexican Water Treaty. Investigations conducted for the comprehensive framework studies indicate that unless the riverflow is augmented, the water supply cannot meet future requirements.

The available surface-water supplies in the Upper and Lower Colorado River Basins have been taxed by expanding agricultural demands and by a generally expanding population which is using water at an increasing per capita rate. To add to the problems of the area, ground water, an important source of water supply in the area is being depleted at a rapid rate in some locations. The decline resulting from the depletion of the ground-water resource has caused some lands to go out of production, significant increases in pumping costs, and a decline in water quality.

Additional water supplies must be developed to keep pace with the increasing demand and the decreasing ground-water storage. Major water development projects such as Hoover Dam, the Colorado River Aqueduct, the All-American Canal System, the Salt River Project, and large ground-water developments have essentially satisifed all of the necessary water requirements in the Pacific Southwest. However, with construction of the Central Arizona Project and with continued expansion of Upper

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*As a background to this article, the reader is referred to the preceeding article which gives the history of geothermal wells in Imperial Valley and elaborates on the important concept of geothermal desalting.

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Basin uses, the day is not far distant when essentially the entire runoff of the Colorado River will be completely utilized. When the Central Arizona Project starts diverting from the Colorado River, the existing level of diversions by California will have to be reduced.

Compounding the quantity problem are water quality problems. The Colorado River Basin is characterized by highly saline soils and many saline springs which add significant quantities of salt to the river. The salinity of the river is increasing and, without a major water quality improvement program, projections indicate that the total dissolved solids (TDS) in the Colorado River at Imperial Dam (Figure 1) will increase from about 830 parts per million (ppm) at present to more than 1,150 ppm by the turn of the century. The Colorado River water would then become unsuitable for many of its present uses.

AUGMENTATION FROM GEOTHERMAL RESOURCES

Serious attention is being focused upon the geothermal resources underlying the Imperial Valley of California for augmentation of the Lower Basin's water supply. Geothermal interest is shared by many other groups, Federal and non-Federal, public and private, because of the potential of this resource to resolve pressing problems of meeting water and power demands of the future.

Geothermal deposits have long been known as a source of energy for the production of electricity. Other major opportunities for development exist when geothermal heat is stored in the form of a hot brine, as in the case in the Imperial Valley and in the vast majority of geothermal deposits. In this situation, the resource has the potential to yield economical new supplies of fresh water by desalting as well as mineral by-products and the production of electricity. With proper planning, this resource may be economically developed for all of these purposes while still protecting environmental quality. A multipurpose development will produce lower cost products than single-purpose development.

On the basis of preliminary studies, developmental concepts for water production have been prepared including many factors that must be considered for optimum utilization of the resource. The geothermal program outlined in this report would be developed in three stages: the Research and Development Stage, the Demonstration Stage, and the Large-Scale Development Stage.

Stage 1: Research and Development Stage

This stage which is now in progress would, through extensive geological, geophysical, and water chemistry investigations, determine the potential and extent of the geothermal resource. Test and disposal wells would be drilled to obtain fluids for testing and determining feasibility of injecting residual and replacement fluids into the periphery of producing zones. Pilot and prototype desalting plants would be constructed and operated to develop data for subsequent stages. Alternative concepts would be investigated to determine the most feasible plan of developing the total resource.

Prime questions in this, as well as any other geothermal development, are the quantity, quality, and thermal properties of the geothermal fluid. A thorough geothermal investigation program is underway to adequately define the origin of the fluids, recharge to the basin, fluid temperatures and pressures, reservoir porosities and permeabilities, recoverable quantities of hot brine, and the vertical and horizontal extent of hot brine producing zones.

Deep test wells will determine the extent and the quality of the geothermal resource of the thermal anomaly. Test injection wells will be drilled and operated to investigate the technical factors related to acceptance of brine in the deep subsurface reservoirs. As data are collected and interpreted from each test well, further drilling and testing would be programed based on results of previous work. Checkpoints would be established as the investigations proceed to allow for study and decisions to be made as to the next steps to follow.

Little is presently known concerning the desalting of geothermal brines, and various desalting techniques must be researched to determine the most feasible desalting process. It is expected that technical problems would be resolved during the present Research and Development Stage program, and that many improvements and refinements would be made to the basic development concept. The research program would culminate in the design and construction of a prototype desalting plant.

Environmental aspects would continue to be analyzed. The emission of deleterious gases must be controlled, and environmentally acceptable means for disposal of waste products such as silica and calcium sulfate must be studied. The location and arrangement of plant facilities would be analyzed to determine the type of installation that would be most suitable to the environment.

Alternative plans for the location of conveyance features would be investigated to determine the best plans. Various points for delivery of desalted water to the Colorado River would be studied and alternative sources of water for injection and cooling purposes would be investigated to determine optimum locations.

It should be emphasized that refinements in the various concepts will probably lead to lower costs, higher reliability, and technological improvements in processes. The unknowns that now exist should be largely resolved by the present research and development program, but some of the unknowns would remain unresolved until undertaking other stages. Plans for large-scale geothermal development, derived after these studies are completed, would be primarily dictated by economic and environmental considerations.

Stage 2: Demonstration Stage

This stage would demonstrate the feasibility of large-scale development. The concept presented would use a local salty or brackish water supply for replacement fluids such as Salton Sea (Figure 1) or local ground water. The magnitude of the development would be about 100,000 acre-feet of fresh water per year. The investigation of electric power generation would be a part of the program with possible participation by non-Federal power producing entities.

Pumping Salton Sea water would have the benefit of controlling the salinity of the sea which, if unchecked, will destroy the fish and wildlife, and drastically reduce the recreational value of the area. Pumping would primarily provide salt removal from the Salton Sea. Further studies would be required to determine secondary measures which would optimize benefits associated with salt removal. These and other factors are being considered in a separate study conducted under the leadership of the Bureau of Sport Fisheries and Wildlife of the Department of the Interior.

Stage 3: Large-Scale Development Stage

This stage could augment the Colorado River by delivering several million acre-feet of desalted water annually with associated electric power production. This volume of output would require importation of Pacific Ocean or Gulf of California water for replacement fluids. Cost of desalted water produced and delivered is estimated to range from $100 to $150 per acre-foot. It is anticipated that the production and marketing of any commercial power available would be a joint endeavor with Federal and non-Federal power suppliers.

Initial analysis of this stage does not reflect the large water quality improvements that will accrue or major technological breakthroughs that could occur in preceding stages. Even comparatively minor technical advances could reduce costs considerably. For example, if the 10-year estimated life of wells can be improved to 20 or 30 years, large cost reductions can be effected.

Water quality improvement would be an important function of augmentation from geothermal reserves. It is estimated that the addition of 2.5 million acre-feet of desalted water containing only 20 ppm of salts to the Colorado River at Parker Dam would lower the average annual salt concentration significantly. If the salinity of the river reaches the projected value of about 1,150 ppm at Imperial Dam, a reduction to approximately 850 ppm could be obtained. The actual reduction would depend upon the salinity of the river at the time of augmentation. If necessary, to avoid an adverse environmental impact to Lake Havasu the desalted water would be cooled and delivered at 75° F, a temperature approximately the same as the lake water temperature.

Several potential delivery points of desalted water from Imperial Valley would provide varying degrees of improvement in quality. Delivery as far upstream on the Colorado River as possible, such as Lake Havasu or Lake Mead (Figure 1), would provide the greatest benefits that would apply to the entire basin and would include improvement of the Colorado River quality as a major function.

Other possible sources of augmentation measures are currently being investigated as directed by the Colorado River Basin Project Act of 1968, such as weather modification, desalting of sea and brackish waters, water salvage, reuse of waste water, watershed management, and irrigation management. The results of these studies and of the geothermal investigations would provide information for optimization of augmentation measures.

PAST INVESTIGATIONS

Geothermal investigations by the Bureau of Reclamation to date have included thermal test drilling in the East Mesa area of Imperial Valley between the cities of El Centro, California, and Yuma, Arizona (Figure 1). This work was accomplished in cooperation with the University of California at Riverside (UCR) through a joint investigation program. Research contracts with the University have totaled about $500,000 from 1968 to date. In January 1971, the Bureau became actively involved in the program

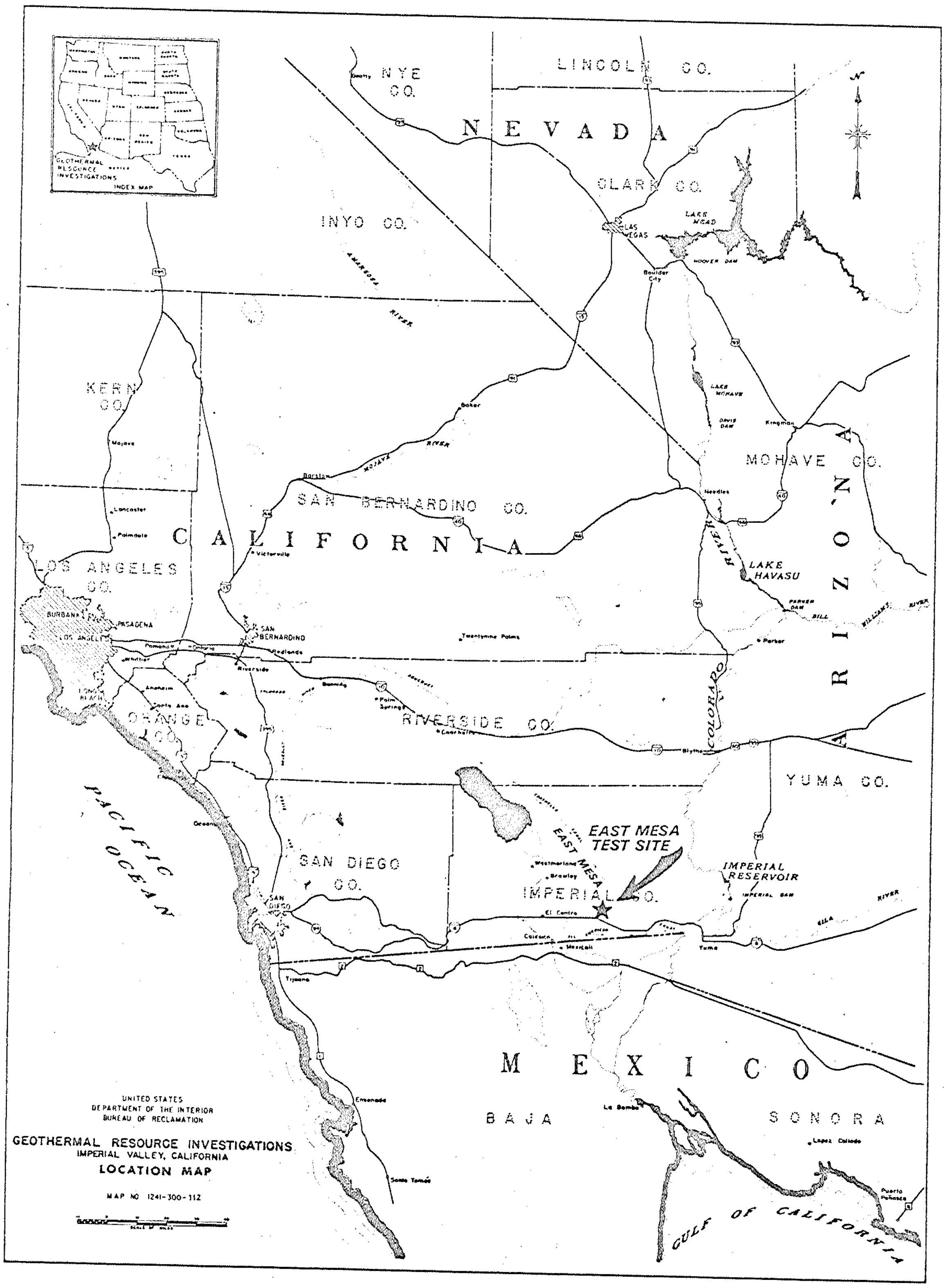

Figure 1. GEOTHERMAL RESOURCE INVESTIGATIONS LOCATION MAP

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by drilling and logging geothermal anomalies identified by UCR. An extensive gravity, resistivity, magnetic, heat flow, and geological investigation program by UCR provided the data required to locate the most promising anomaly, the Mesa anomaly. The University has recently conducted chemical isotopic studies and micro-earthquake monitoring work under contract with the Bureau of Reclamation.

The Geological Survey is assisting the Bureau of Reclamation in determining the quantity and quality of water in storage and the quantity of recoverable hot water. A level network for a subsidence monitoring program has been established in Imperial Valley in cooperation with the State of California, Imperial County, Imperial Irrigation District, Geological Survey, National Oceanographic and Atmospheric Administration, Bureau of Land Management, and the Bureau of Reclamation.

The Imperial Irrigation District has shown an intensive interest in geothermal development and has contributed $15,000 in funds to the Bureau of Reclamation for research and investigations of geothermal resources in Imperial Valley.

In 1971, eighteen temperature holes were drilled in the East Mesa and Glamis-Ogilby areas. The holes ranged in depth from 375 to 1,468 feet. Currently, a number of shallow test holes of less than 1,000 feet in depth are being drilled for further definition of the Mesa anomaly, and to provide temperature data for the location of future production wells.

CURRENT INVESTIGATIONS

Geothermal Wells

Significant progress to date includes the drilling of one 8,030-foot exploratory production well (Mesa 6-1) in August 1972 and a second well (Mesa 6-2) to a depth of 6,005 feet in August 1973. Both wells are located at the East Mesa test site on the Mesa anomaly (Figure 1). The test desalting units have been installed and operated at the Mesa 6-1 well site. Figures 2 and 3 illustrate the general layout of the geothermal well Mesa 6-1, desalting units, brine holding pond, and associated surface equipment.

At Mesa 6-1, a 9-5/8-inch production casing was installed from the surface to a depth of 7,292 feet below ground surface. A 7-inch liner was hung in the bottom of the production casing to a depth of 8,015 feet. The liner was slotted at selected intervals for a length of 426 feet with slots 1/4-inch in width (Figure 4).

The bottom hole temperature of Mesa 6-1 is about 400° F with a static pressure of about 3,100 pounds per square inch. As initially completed, the well flowed (with the 8-inch automatic control valves completely open) at a wellhead fluid temperature of about 225° F and a pressure of 10 pounds per square inch (gage). Liquid flow rate has been measured at about 200 gallons per minute over a weir. The salinity is about 17,000 ppm (Table 1). Recently, by downhole casing perforation methods, selected intervals from 6,800- to 7,100-foot depth were opened. The well has been blown to clear loose sands and well drilling debris and flow tests will be made.

The second deep well, Mesa 6-2, was drilled in August 1973 to a depth of 6,005 feet on the anomaly about 1,475 feet west of Mesa 6-1 and a 7-5/8-inch production casing was placed from the surface to a depth of 5,951 feet. The lower 506 feet of the production casing was slotted. Refer to the schematic profile of wells 6-1 and 6-2, Figure 4. Recent testing of Mesa 6-2 has shown a bottom hole temperature of 370° F. Wellhead temperature of 304° F at 94 pounds per square inch (gage) has been recorded. A complete flow performance curve has been developed for the well and is shown in Figure 5. Liquid salinity has been about 2,400 ppm before flashing (Table 1). The salinity of the liquid concentrates to about 4,000 ppm after flashing.

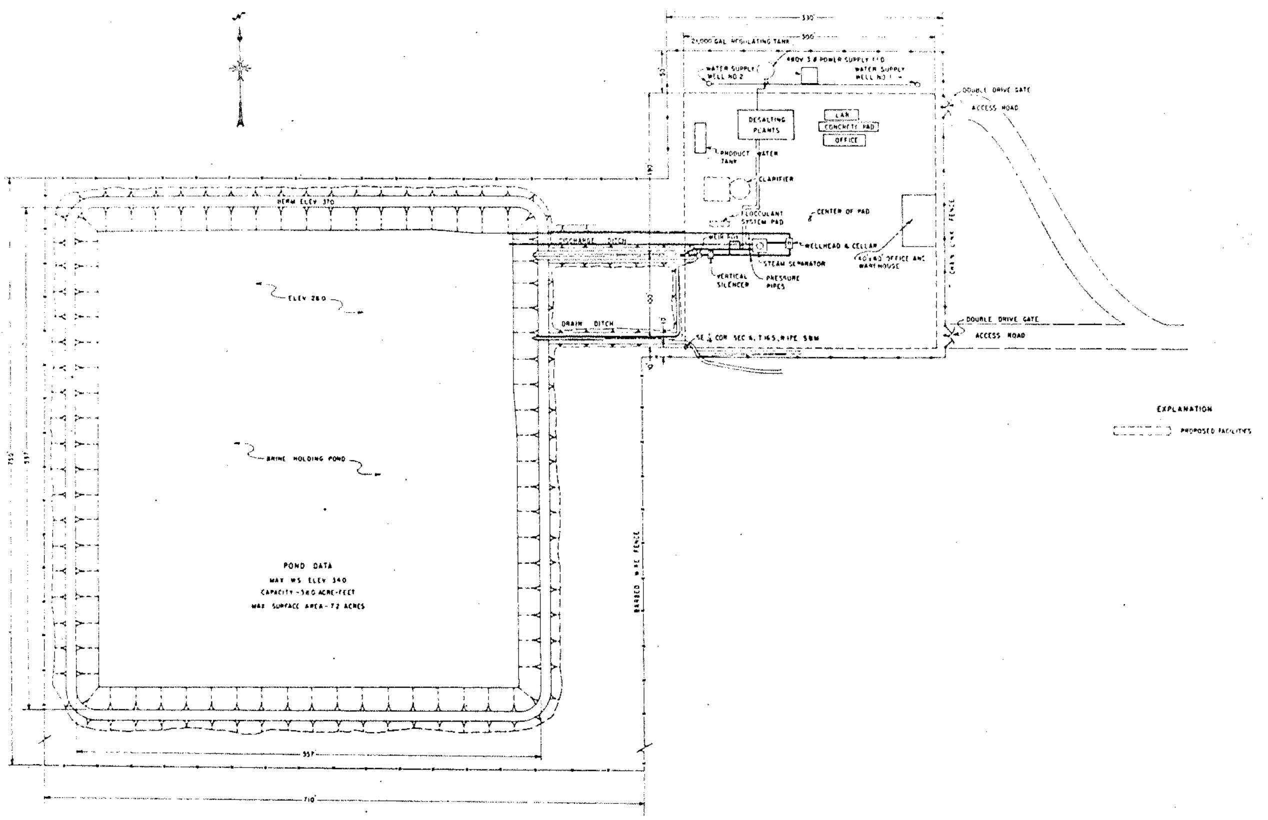

Figure 2. GEOTHERMAL EXPLORATORY TEST WELL
(Well System Layout Plan)

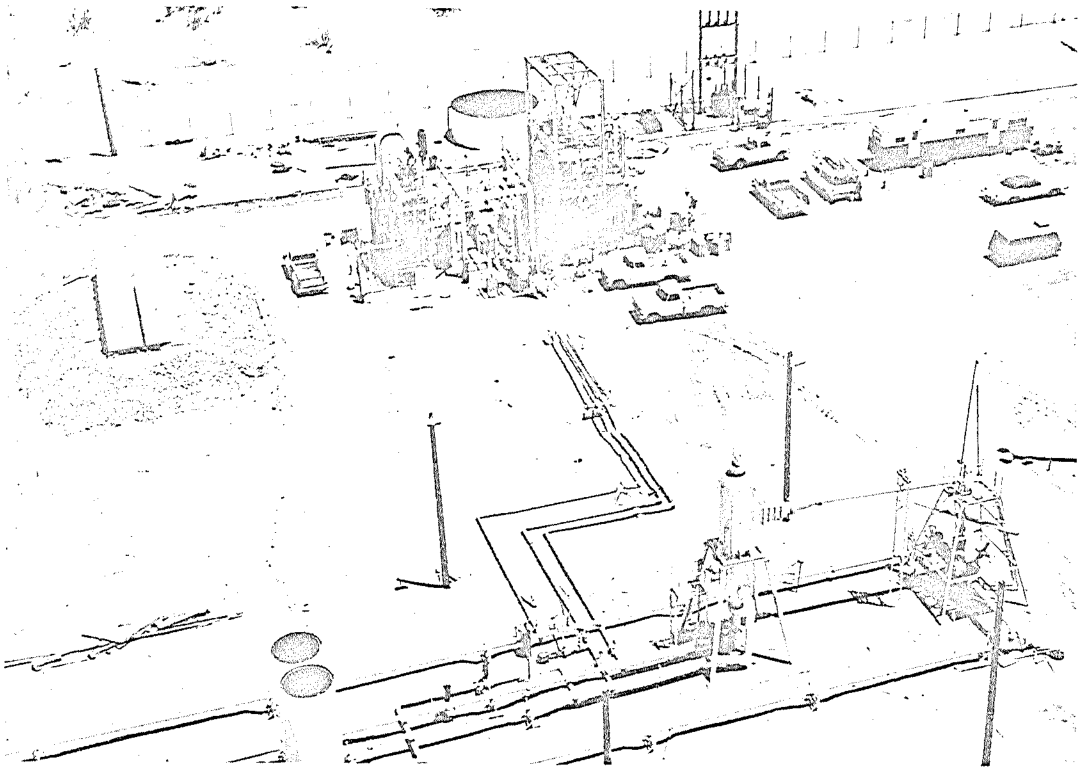

Figure 3. AERIAL VIEW OF THE EAST MESA TEST SITE
(The desalting plants appear at the top; the Mesa 6-1 wellhead is at the lower right with the vertical cyclone separator and twin tube vertical silencer in the foreground.)

TABLE 1

REPRESENTATIVE RECORDS OF CHEMICAL ANALYSES OF WATER FROM MESA 6-1 AND MESA 6-2 IMPERIAL VALLEY, CALIFORNIA

Sample	Date	pH	TDS	Na	K	Ca	Mg	HcO_3	Cl	SO	SiO_2	
W406.2	7-17-72	7.2	1,850	511	44	38	1.3	379	428	370	185	6-1 Drill stem test 5,557 to 5,607 feet
W448.2	8-15-72	6.2	12,620	3,689	391	237	4.2	812	5,457	269	290	6-1 Drill stem test 7,292 to 8,030 feet
W648.2	10-13-72	7.4	30,540	9,619	1,296	1,173	36	96	18,085	20	110	6-1 End of 8 inch lines Well producing steam and liquid
W30.3	1-23-73	6.1	16,180	5,129	632	389	22	305	9,014	20	220	6-1 Thief sample at 7,900 feet well flowing
W433.3	8-6-73	7.2	2,830	918	65	40	--	1,248	776	206	195	6-2 Drill stem test 5,523 to 5,625 feet
	10-23-73	7.7	2,383	760	69	13	--	715	710	202	246	6-2 Surface samples well producing liquid at surface

Note: All constituents are in parts per million except the pH factor

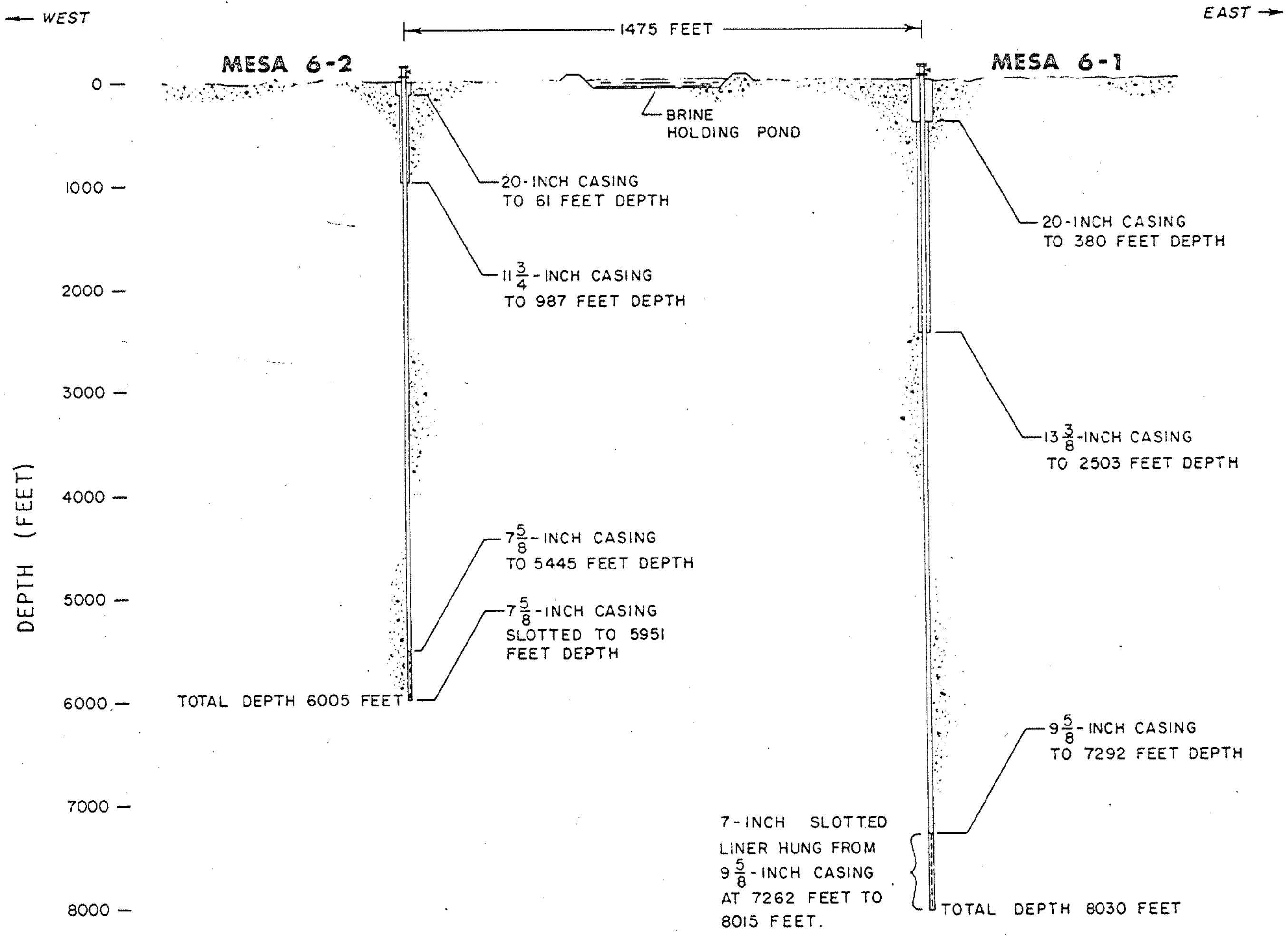

Figure 4. SCHEMATIC DIAGRAM GEOTHERMAL TEST WELLS — MESA 6-1 AND 6-2
(Imperial Valley, California)

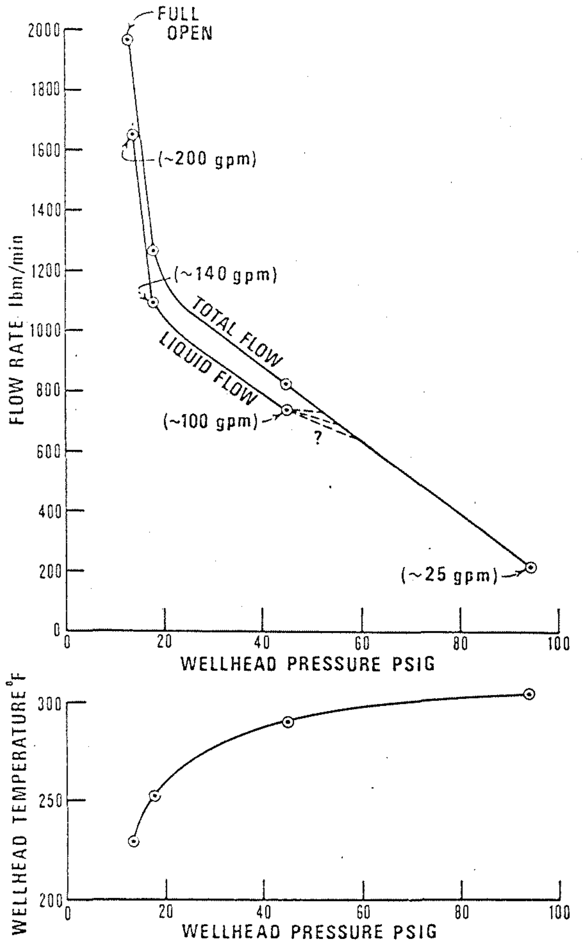

Figure 5. TEMPERATURE, PRESSURE, AND FLOW RATE
(Geothermal Well Mesa 6-2, Imperial Valley, California)

The high pressures from under the earth's surface forces the geothermal liquid into the liner and up through the well's production casing. Thus far, it has been seen that both wells are capable of flowing either a steam and liquid mixture at the surface, or all liquid, depending upon flow rate and pressure conditions. At low flow rates where drawdown is minimal, sufficient pressure is maintained at the surface to keep the hot fluid in a liquid state; at higher flow rates and increased drawdown, pressure within the bore decreases and allows part of the liquid to flash into steam. The performance curve for Mesa 6-2 (Figure 5) illustrates this fact. Downhole pressure and temperature runs have been made in the wells while flowing.

To maintain continuity of operation, the quantities of brine produced during the desalting process will be reinjected into the producing geological formations. Therefore, an injection well will be drilled in the near future to provide for this operation. Prevention of subsidence is an important reason for close attention to solving reinjection problems. A cooperative effort between the Bureau and the Geological Survey is being exercised by establishing a tiltmeter network array to continually monitor both natural and possibly man-made subsidence in the East Mesa area. The effectiveness of the reinjection program will be measured in part by the tiltmeter program. Level networks have been set up throughout the valley for subsidence monitoring as previously described.

Desalting Plants

In cooperation with the Office of Saline Water, two desalting test units have been installed at the East Mesa test site in the Imperial Valley. A multistage flash unit (MSF) was erected at the site by the Envirogenics Company of El Monte, California. The test vehicle was originally erected at the Office of Saline Water's facility at Wrightsville Beach, North Carolina. From tests conducted at that site using synthetic geothermal fluids as feedstocks at up to 400° F, evaluations were made and a vertical tube evaporator (VTE) was designed. The design was developed by the Office of Saline Water and by Burns and Roe of Oradell, New Jersey; the VTE unit was constructed and erected at the Imperial Valley test site by Aqua Chem, Inc., of Milwaukee, Wisconsin.

Because the desalting units operate on separated steam and liquid, a cyclone-type steam separator was installed. It is located near Mesa 6-1 (Figures 2 and 3). Automatic control valves were installed in the connecting piping to control pressures and flow rates from the separator.

Some of the liquid not needed to operate the desalting units is bypassed to the evaporation pond. The pond has a capacity of 38 acre-feet and is lined with a 10-mil thickness polyvinyl chloride plastic material to prevent contamination of the local ground-water system. The plastic is covered with 6 inches of sand for protection.

As liquid is bypassed to the pond, it is reduced to atmospheric pressure and a percentage flashes to steam. A silencer is used to muffle the noise created by the flashing process. A weir box was installed downstream from the silencer to measure liquid flow after flashing has occurred.

In the MSF test unit, designed to produce between 20,000 and 50,000 gallons per day of distilled water depending upon operating parameters, the geothermal liquid is flashed in three successive flash vessels (Figure 6). In each vessel, the pressure is reduced by means of a vacuum system and liquid is flashed to establish a level of energy at equilibrium with the flash vessel ambient pressure. The vapor from each stage is drawn through entrainment separators to reduce the quantity of entrained water droplets and then passed into heat exchangers for condensation into a distilled product.

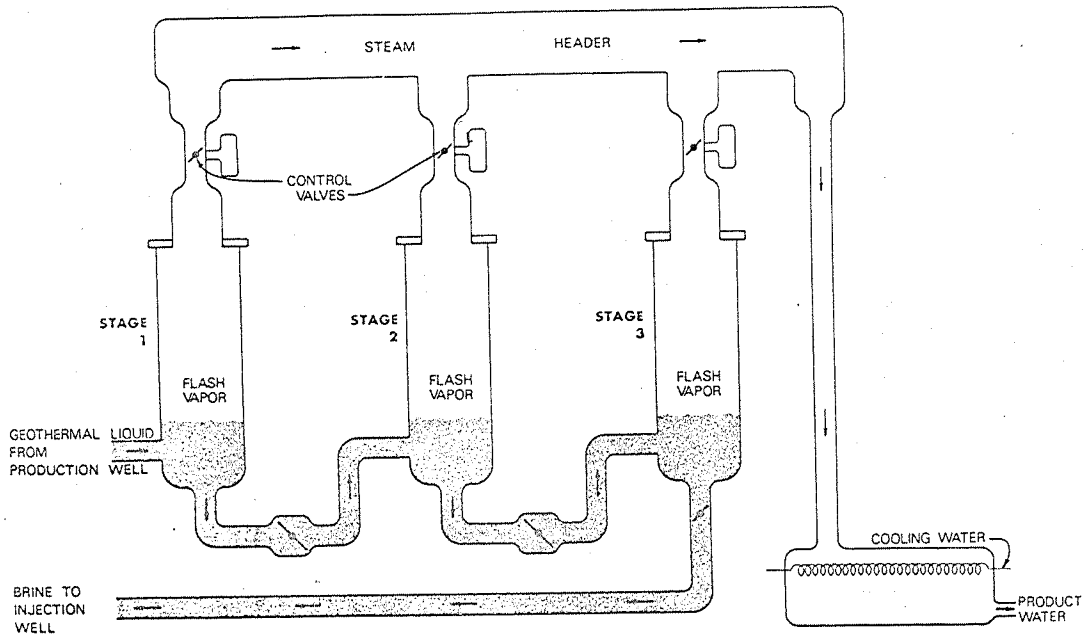

Figure 6. MULTISTAGE FLASH DISTILLATION PROCESS
(Geothermal Liquid from Mesa 6-1)

During the summer of 1973, the MSF unit was operated using geothermal brine feedwater. This was a milestone for desalting since it was the first fresh water processed by desalting geothermal brine under field conditions.

The plant is equipped with automatic control systems to allow for unattended operation and to provide for automatic fail-safe shut downs. Figure 7 is a photograph of the completed pilot plant. Waste brine from the unit is now delivered to the evaporation pond for disposal. Later an injection well will be the method of disposal.

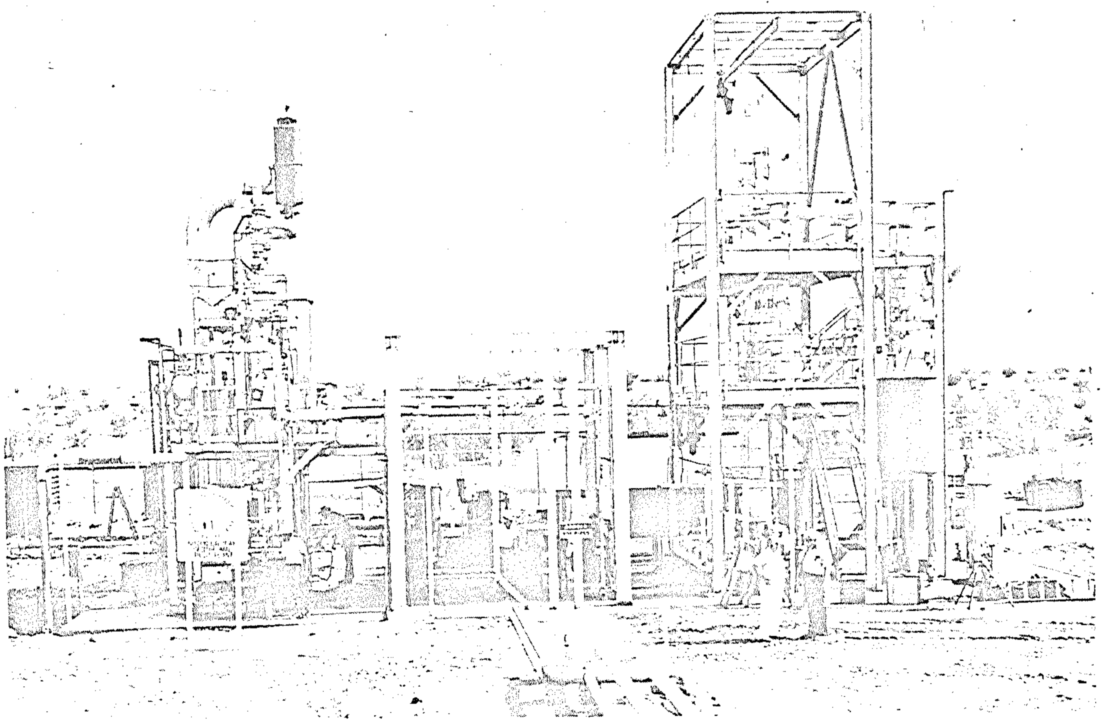

Figure 7. DESALTING PLANTS
(Vertical Tube Evaporator on Right and Multistage Flash on Left)

For past testing purposes, low temperature (225° F) and pressure (80 psig after relift pumping from a wellhead pressure of 10 psig) flows were used to feed the system. Recent downhole perforation in more permeable zones of Mesa 6-1 will, however, provide higher temperature and, in turn, higher production values.

Samples drawn from each of the three stages have shown a product of less than 30 ppm TDS at the first stage (Table 2) to 85 or more ppm TDS in Stages 2 and 3. The lower quality in the later stages is caused primarily by the hydraulic instability at lower than design operating temperatures. Higher feed temperatures will alleviate this problem. The unit was designed for feedwater temperatures of over 300° F.

TABLE 2

QUALITY OF PRODUCT WATER FROM STAGE 1 SAMPLE

MSF Desalting Plant, August 1973
Geothermal Resource Investigations
Imperial Valley, California

pH	9.5
Constituent	ppm
Sodium	4.0
Potassium	0.8
Calcium	1.8
Magnesium	0.1
Boron	0.2
Iron	0.1
Carbonate (CO_3)	9.2
Bicarbonate (HCO_3)	1.2
Chloride (Cl)	3.5
Sulphate (SO_4)	4.8
Fluorine (F)	0.1
Phosphate (PO_4)	0.2
Silica (SiO_2)	1.5
Total Dissolved Solids	27.5

Start-up has proven to be quick and reliable. Stability and product production have been established usually within 20 minutes of cold start-up.

Table 3 presents a summary of two typical steady-state operating modes using low temperature brines. This set of operating parameters has been found to be stable and quickly established upon start-up. Around-the-clock continuous tests have been run using these parameters. The use of higher temperature feedwater will allow more flexibility in stable operating modes.

TABLE 3

SUMMARY OF SHAKEDOWN OPERATING CONDITIONS

Multistage Flash Distillation Unit
Geothermal Resource Investigations
Imperial Valley, California

	Test Runs	
	August 4, 1973	October 3, 1973
Brine Feed Rate, gal/min	94	75
Maximum Feed Rate Temperature, °F	223	222
Brine Concentration, ppm TDS	~30,000	~30,000
Brine, pH	~7.4	~7.4
1st Stage Brine Inlet Temperature, °F	223	222
2nd Stage Brine Inlet Temperature, °F	201	206
3rd Stage Brine Inlet Temperature, °F	183	184
Brine Blowdown Temperature, °F	170	167
1st Stage Flashdown, °F	22	16
2nd Stage Flashdown, °F	18	22
3rd Stage Flashdown, °F	13	17
Overall Flashdown, °F	53	55
1st Stage Operating Pressure, in.-Hg	7	3
2nd Stage Operating Pressure, in.-Hg	10	8
3rd Stage Operating Pressure, In.-Hg	18	19
Cooling Water Inlet, Main Condenser, Temperature, °F	99	98
Cooling Water Outlet, Main Condenser, Temperature, °F	125	122
Cooling Water Flow Rate, Main Condenser, gal/min	97	120
Product Water Outlet, Main Condenser, Temperature, °F	118	128
Product Water Rate, gal/min	~4	~3 to 4

The VTE test unit is now undergoing shakedown operations to determine equipment operational characteristics. Hot geothermal liquid (after separation from the steam) flows through a bundle of vertical tubes located inside a chamber (Figure 8). As the liquid flows through the tubes, it receives additional heat from the steam which surrounds the tubes. This heat exchange process converts some of the liquid into steam and at the same time condenses some of the steam into fresh water. To obtain overall high efficiency, the process is repeated in several evaporator chambers (evaporator effects). These effects are arranged in series and repeat the beating condensing cycle several times, each time at lower pressures and temperatures. During initial operation of the unit, geothermal liquid will flow in the upward direction through the tubes. At a later date, the equipment will be modified to run in the downflow mode as it is called when liquid flows downward through the tube bundles.

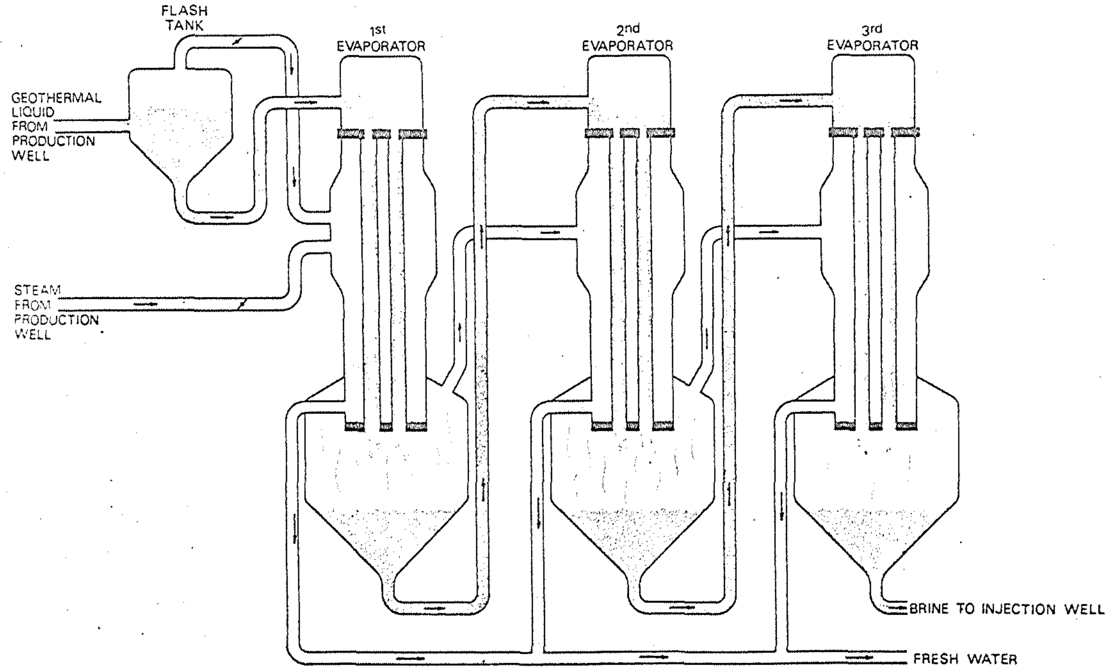

Figure 8. VERTICAL TUBE DISTILLATION PROCESS
(Geothermal Liquid in Downflow Operation)

In any heat exchange process, strict attention is directed toward heat-transfer characteristics of the heat exchanger and any event which may alter an as-designed heat-transfer constant. Increased resistance to heat flow, by scaling (material buildup) or corrosion on transfer surfaces, results in a decrease in design efficiency. The major research involved in the VTE is that of establishing tube sizes, flow rates, materials evaluation, and possibly chemical pre-treatment methods to keep heat transfer at its maximum value.

With new technology gained and design parameters established in running the existing units at steady state, and nonscaling and non-corroding conditions, larger plants can be built. It is proposed that a 200,000- to 500,000-gallon per day pilot plant be constructed in the next step of testing. Ultimate quantities of desalted water could be in the range of 2 to 3 million acre-feet annually.

MULTIPURPOSE DEVELOPMENT

While production of desalted water is the paramount goal of the program, possibilities for multipurpose development are being evaluated. It is necessary to use a certain amount of energy for transport of the product and injection waters. This needed small amount of energy can easily be taken from a small geothermal powerplant. Figure 9 illustrates the theoretical available electric power from Mesa 6-2 that could be produced at the generator terminals of a plant using a secondary material such as freon or a propane-butane mixture as the working fluid. The binary type (employing a secondary working fluid) plants are particularly fitted for use in extracting energy from the Imperial Valley's East Mesa steam-water mixtures where kinetic energy is low, but where heat energy is significant. Large powerplants in the valley using this method would be capable of making a contribution in the current energy shortage situation.

Recovery of marketable mineral products from wastebrine would be an important part of the multipurpose development. Other Government agencies and private industry are also involved in the research of this subject.

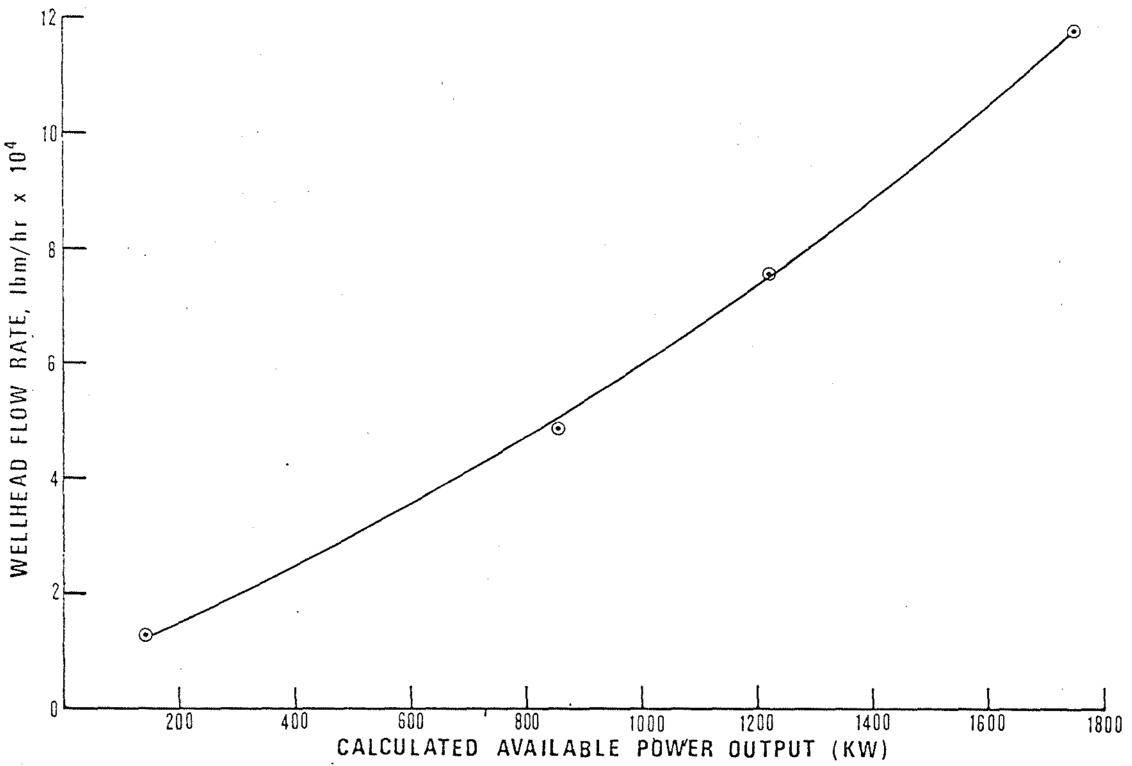

Figure 9. THEORETICAL POWER OUTPUT BINARY TYPE POWER PLANT
(Geothermal Well Mesa 6-2, Imperial Valley, California)

PROPOSED FUTURE WORK

Future work will involve a continued program of investigations and development on the Mesa anomaly and the investigation and delineation of other geothermal anomalies.

The underground portion of the R&D program will consist of exploratory well drilling to define the full range of geological and hydrological parameters, production well drilling and operation, and injection well drilling and operation as required. The above ground portion of the program will consist of the construction of wellhead assemblies, filters for reinjection brines, desalting plants, piping, and possibly test power generating facilities.

More detailed data are needed at the most promising Mesa anomaly. This can be accomplished by drilling several deep holes to the steam-producing zones. The Bureau's geothermal program includes the drilling of additional deep test wells to some 6,000 feet. Information developed from proposed heat measurements, core samples, logs, and flow tests would substantially improve the definition of the Mesa anomaly and provide the necessary data for preliminary design of future desalting plants. Preliminary information for possible test powerplant design would also result from these data.

Reconnaissance geological exploration by test wells and geophysical surveys are required in other areas of Imperial Valley, such as the West Mesa area and the Glamis-Ogilby area, as well as further work of the same kind in the East Mesa area. Important investigations to be accomplished in new areas are gravity work, resistivity surveys, and heat flow surveys. These surveys appear to be the most economical methods for locating thermal anomalies in the geological environment of Imperial Valley.

Future investigations would be extended to other promising areas such as the Gila River drainage in Arizona, south and east of Yuma. Relatively inexpensive gravity surveys, aeromagnetics, and, possibly, infrared scanning processes could readily define promising geothermal areas.

Among the first studies required are the determination of processes that would allow the low cost energy of this high temperature feed source to be used to advantage, while coping with the particular problems that would arise

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because of the expected corrosion and scaling tendencies of the geothermal brine. Silica within the geothermal brine will tend to scale equipment as the brine cools. Furthermore, particles entrained by the high velocity liquid may have strong eroding characteristics. This latter effect plus the corrosiveness of dissolved H_2S require that special emphasis be placed on resistant but economical construction materials. Chemical treatment of the geothermal brine, upstream of the distillation plant, might prove to be the most effective means of avoiding some of these problems.

Early developmental efforts would be directed toward the recovery of by-products from the residual brine and the disposal of wastes from the distillation plant. Since different brine compositions are expected from different geothermal fields, the techniques for both by-product recovery and waste disposal would be difficult to identify prior to actual tests of specific well outputs. Data must be developed in all areas to permit the handling of those feedstocks.

The Office of Saline Water's experience with sea water indicates that the appropriate size for a prototype plant of this type is 2 to 3 million gallons per day of product water for an annual production of about 2,000 to 3,000 acre-feet. This size plant would amply highlight both the construction and operation problems likely to be encountered in large geothermal desalting plants. Data obtained from the prototype plant would permit the extrapolation of design parameters to the large plants. Desalted water would be delivered to local canal systems during test operations.

The Bureau is working with the Department of Agriculture in establishing a test agriculture plot to investigate the use of high quality desalted water for direct application on crops common to Imperial Valley. The plot will be located at the East Mesa test site and will utilize product water from the desalting plants.

Concurrently, other tests would be run on the effect of desalted water flowing into the Colorado River system such as at Lake Havasu and the full effects of withdrawing water from the Salton Sea. Colorado River operations must be fully investigated to determine the effects of delivering desalted water to local canal systems in Imperial Valley. The effects of augmentation on power releases from Hoover, Davis, and Parker Powerplants must also be analyzed.

CONCLUSION

The deposit of geothermal heat is one of the Nation's relatively untapped resources. It has been proven to have the potential for providing fresh water, power, and in some areas, mineral by-products without associated air pollution. Existing use of geothermal energy has been limited because of technological problems and the accessibility of geothermal resources relative to other sources of energy. With the shortage of electrical energy and the changing economic scene, new developments of geothermal resources are expected to increase rapidly in the near future.

Here in the Imperial Valley we have a geothermal energy test site that has caught the attention of a great many people who are working in various ways to solve the problems related to water resources, electric energy, corrosion control, mineral extraction, agricultural hydroponics, space heating, and air conditioning - to name just a few of the potential uses for geothermal energy.

Several members of the scientific community -- each in his own particular field -- are approaching technological solutions to these problems. Unfortunately, most of the scientific achievements are still on the drawing boards or, at best, have been proven only under laboratory conditions.

What is badly needed is a setting where further testing and research can be performed under actual field conditions with producing geothermal wells. We have such a setting on the East Mesa of the Imperial Valley and have initiated a program that will make these facilities available as a field laboratory to selected scientists for testing and research. In view of the present oil shortages, we can expect that a substantially larger amount of funds will be made available for the research and development of other energy resources such as geothermal.

There are literally trillions of Btu's locked up in the magma of the inner earth waiting for our technology to advance to the point where it can be utilized for greater benefit to mankind. It is becoming increasingly important that we take the necessary steps to begin capturing the energy from this latent resource.